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EVOLUTION TOWARDS 5G IN LTE TECHNOLOGY

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ABSTRACT

LTE (Long Term Evolution) has become one of the fastest developing cellular technologies in the world. With its release 11 and 12 it has provided its user with the best 4G network features and has successfully fulfilled the requirements of IMT-Advanced. Now, it is working on its way for developing LTE to achieve 5G technology features in its upcoming releases. It is expected that there would be problems of increasing data traffic in future as multiple devices would be accessing the network at one time. Also, there would be an increase in the demand for mobile networks since users always look for the best user experience. These requirements have been the driving force for LTE to establish 5G networks. With enhancements made in release 12 and 13 such as Device to Device technology, Machine type communication, integration of WIFI with LTE, small cell enhancements and public safety features LTE has achieved maximum efficiency and has proven to be useful for many public safety organizations. Furthermore, the releases 14 and 15 have been aimed to provide 5G technology features with data rates greater than 1GBps and capacity by 1000x. This paper gives an overview of LTE technology beyond release 12 and describes the features to be provided in future by 5G networks.

KEYWORDS: 5G, 4G, 5G with LTE, Release 12, Release 13, HSPA, WiFi with LTE, LTE in Public Safety

INTRODUCTION

There has been a growing demand in mobile data traffic and in the coming years, handling huge data traffic explosion would be very challenging for operators. At the same time, quality of service of the network must be maintained up to the expected standards. For this, 3GPP has made improvements in LTE to provide data rates greater than 1GBps and bandwidth more than 100MHz. Beyond release 12, it has introduced features like 3D beam forming, D2D communication and other backhaul enhancements to enhance the capacity and data speed of the existing networks. Its main priority is to make LTE an energy saving and cost efficient network. Also, it is supportive for diverse applications and traffic types with small cell enhancements and integration of WIFI with LTE.

Along with the view to achieve demands from users, meet traffic issues and provide users with good QoS (Quality of Service), LTE is looking forward to develop high level quality VOIP and data services in its releases 14 and 15 for the fifth generation. With these improvements, it is on its way to make LTE capable for providing 5G radio access technology. 5G aims to provide a peak data rate up to 10GBps enhancing data speed at cell sites.

It will provide ubiquitous connectivity, ease of use, good performance, safety and high reliability. A great degree of personalization can be achieved with different user centric services. Also, it will support more use cases and with the integration of HSPA, it will provide maximum coverage and more capacity. With all these requirements, 3GPP will implement 5G technology by 2020.

Release 12 and Beyond: General Enhancements

3D Beam Forming

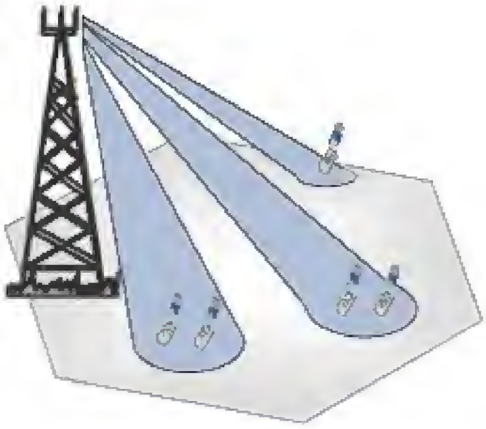

Figure 1: 3D MIMO Beam Forming

In the future, there would be a high increase in the traffic volume. With this view in mind, enhancements have been made in small cells and macro cells in order to achieve high capacity and maximum network coverage [1]. Enhancements in macro cells have become possible due to the advancements in antenna technologies. By the use of AAS (Active Antenna Systems) where active antennas are integrated with RF components vertical sectorization or sectored specific elevation beam forming can be achieved which gives a significant improvement in the sector capacity as compared to a single beam system[10].

Vertical sectorization can be developed by two techniques. They are:

- **UE Specific Elevation Beam Forming**

This beam forming technique adds UE specific vertical beam steering to existing azimuth closed loop SU/MU MIMO methods [10].

- **3D MIMO Technique**

3D MIMO techniques simultaneously exploit both azimuth and elevation dimensions of the multipath channel according to user- specific basis [10].

Overall, these techniques help in improving the cell-edge and sector capacity of the network.

- **Improvements in Small Cells**

Small cells and hotspots face the highest data traffic pressure. Two kinds of scenarios need to be considered for small cell enhancements [1].

In the first scenario, different frequency layers are being used for small cells known as frequency separated localized access. In the second scenario, macro and Pico cells use same frequency and small cells are integrated into the network. This is known as frequency integrated localized access and it proves to be more promising for enhancements [1].

Depending upon the scenario, different methods are used to support UE's to identify cell sites. For cell enhancements, TDD proves useful for managing data traffic fluctuations in the cell sites whereas the FDD allows macro coverage in low frequency bands [3]. The joint operation of FDD and TDD in heterogeneous networks enables efficient

usage of resources for many operators. Small cells provide data at a faster rate with a largely improved link due to close proximity with each other [3], whereas macro cells provide cell wide system information and radio resource control.

- **Machine Type Communication(MTC)**

In LTE-A, 3GPP has focused on network robustness when multiple MTC's where connected together [21]. Now, in LTE-B i.e. release 12 and 13, it is focusing on supporting various MTC application scenarios.MTC is the automated exchange of information between different devices (usually sensors) and core central network [5].

MTC's satisfy the basic requirements like low energy consumption, low complexity and long battery life. In MTC, data is first collected by a device and then converted to digital form and after analysis it is sent over the LTE network. The application receives the data through the network and after assessment returns an appropriate response back to the device [5]. MTC's provide time controlled and secure communication between devices. A large number of devices can be handled per cell. MTC devices are being used in various areas like smart home technology, security systems, navigation etc. to provide good network coverage and efficiency transmission [6]. It also provides extended coverage options at challenging locations.

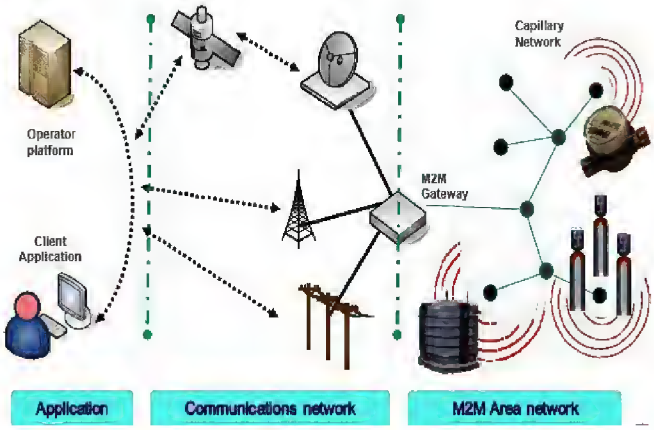

Figure 2

- **Device-To-Device Communication (D2D)**

In device to device communication, one device detects the presence of another device by carrying out search in its proximity or surroundings and then carries out communication [2]. D2D communication and D2D discovery have enabled LTE to carry out proximity based services (ProSe) [9].

In D2D discovery, the LTE air interface enables a UE to identify other UE's in its proximity. The discovery function in D2D is classified into two types as restricted discovery and open discovery in terms of whether permission is required or not. D2D communication involves the use of LTE interface for communication between two UE's through the set of a direct link. The communication doesn't involve the routing of eNB's (e Node B) and the core network [9].

The main advantage of using D2D is that they prove useful for providing spectral efficiency and reduced communication delay [8]. Although D2D can get support from the base stations for various control functions, it can work efficiently even if the connectivity between base station and D2D fails. This key feature proves D2D to be useful for public safety applications [12]. The ProSe feature plays an important role in public safety whenever the network accessed by devices fails.

- **Public Safety Applications**

One of the aims of LTE is to provide industry support to commercial networks as well as public safety organizations. Today public safety organizations are working their way to use LTE technical standards for carrying out public safety operations [13]. Previously, commercial carriers were used for the transportation of public safety data which did not guarantee the quality of service. Also, public safety systems demand good inter-operability, reliability and resilience [7]. LTE fulfils these requirements by introducing a public safety feature known as Mission Critical Voice using proximity based services (ProSe) and Group Calling[13][14].

Group calling in critical voice communication provides push-to-talk feature, voice and video and data services. In group communication, the work is divided between the RAN layer, Core network and Application Layer Functionality. Efficient media transmission between devices is carried out by the RAN layer in either point–to-point or point-to-multipoint manner. The Core network connects the media from the sender to the RAN node for distribution to the group members [7]. The setup and control of group membership and floor control/arbitration is carried out by the Application Layer Functionality. The group calling feature thus allows only group members to communicate and share data in that group. LTE allows proximity along with group calling. When one or more UE is outside LTE cell site but in proximity to a public safety group member it allows ProSe to extend the group call to that particular UE. This feature plays an important role whenever the network accessed by devices fails.

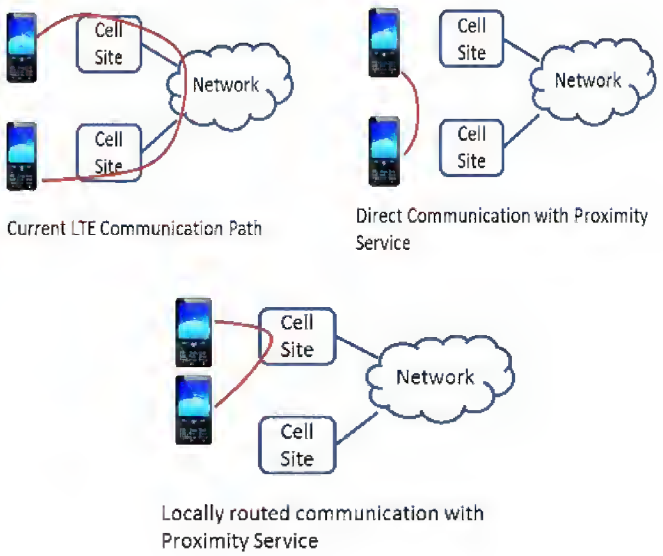

Figure 3

- **E-Utran Operation for Public Safety**

This feature of public safety is being planned to be released in release 13 of LTE. In a normal operation if there is a connection loss between the base station and the core network, then the operation would cease. This can be prevented through E-UTRAN operation [7]. A base that has lost its connection to the core network can re-route by connecting another base station with a functioning connection. With E-UTRAN operation communication services can be provided between public safety officers by extending the range provided by proximity services, even if the connection from the base station is lost. Thus, E-UTRAN operation offers resilience to public safety systems.

- **Integration of Wi-Fi with LTE**

As the data traffic is going on increasing, capacity of networks to handle the load must be boosted. With the interworking and integration of WIFI with LTE, cellular operators have seen a significant increase in the traffic handling capacity of the network [3]. Heterogeneous networks with WIFI use RAT's (Radio Access Technologies) boost peak capacity at hotspots and improve cell edge performance [4]. In WIFI integration, capacity of the network can be enhanced by the following ways:

- **Enhancements in Macro Networks:** With more antennas, additional licensed spectrum, better processing capabilities and better carrier aggregation, macro networks can be enhanced to provide better network coverage [4].
- **Densification of Networks:** Network densification reduces the number of cell sites and network performance is less sensitive to the traffic location.
- **Small Cell Deployments:** Small cell deployments with low power nodes provide benefits such as providing enhanced support for mobility between power nodes and energy efficient load balancing.

WiFi Offloading

WiFi Offloading is a method used by mobile operators in which data traffic is moved from Femto radio interface to the WIFI radio interface in order to solve the capacity crunch problem in mobile networks [16]. This method consists of three elements that is Discovery of WIFI-APs, selection of appropriate WIFI-APs and accessing the WIFI network. The discovery of WIFI-APs is done by carrying out a search in the vicinity of UE [16]. The WIFI-APs are selected according to a prioritized list of radio accesses and are configured either in the UE or dynamically provisioned by the MNO using ANDSF procedures. Accessing the WIFI network can be password based or according to user credentials with the mobile operators.

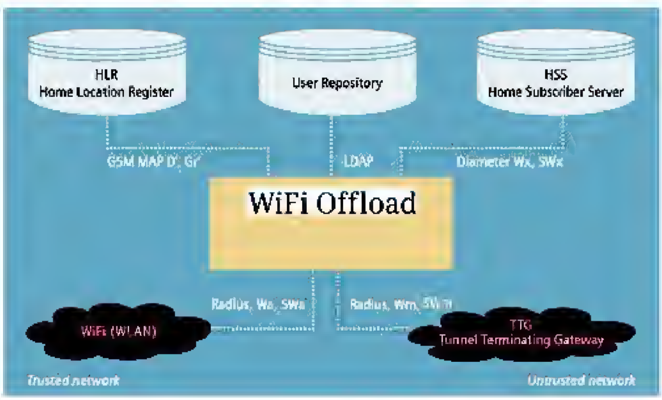

Figure 4

Overall, WIFI integration allows radio resource management and improves overall mobile broadband performance.

FEATURES OF 5G

The fifth generation communication system will be an advance system converges with multiple radio access technologies integrated together. It will efficiently support the services and applications by sufficing the requirements of

the society by the year 2020 and beyond [19]. 5G will be the continuous development of RAT's to meet the increasing demand of the future. It can be characterized as data, connectivity and user experience. 5G will realize networks capable of providing zero-distance connectivity between people and connected machines.

Requirements and Characteristics

From the operator's point of view, the requirements and characteristics are as follows:

- The 5g technology requires thousand times cellular traffic compared to current traffic volume [17]. For example, it requires data traffic greater than 100Gbps/km.
- 100 times more connections are required to obtain larger throughputs, for example more than 1 million connections/km [17].
- 5G provides users with 10Gbps peak data rate. It provides more than 10Mbps affordable per user data anywhere and anytime and 100 Mbps for some special users.
- Lower latency, delay in milliseconds (ms) for end-to-end user plane, and within 10ms for control plane are some of the pivotal characteristics of 5G technology [17].
- It also facilitates higher spectrum efficiency, 3-5 times higher than today for large area coverage and even higher for special cases.
- It is relatively cheaper i.e. nearly 0.001 times of the cost per bit than today.
- It has higher energy efficiency, nearly 0.001 times that of energy consumption per bit than today.

From the consumer's point of view, the first and the second generation technologies only provided basic voice calls and short message services (SMS), while the third and the fourth generation systems provide multimedia services (MMS) along with voice calls and SMS. In 5G mobile system the user experience will be enhanced in multiple aspects such as higher demand, good performance, ease of use, affordability, safety and reliability, personalization etc. It is estimated by a study that future mobile data consumption will be on average 1Gbytes per day per user in 2020 and beyond.

3GPP is now focusing its efforts to fulfill these requirements.

Convergence and support of IoT (internet of things):

With IMT applications penetrating into multifarious industries and continuously increasing the popularity of IoT, service variety and flexibility of IMT also increases rapidly. From the point of view of data rates, 5G efficiently supports small metering services, where a small packet (tens of bits) is transmitted in period of ten days or even more, and also the interactive 3D holographic video service where the data rate will be in the range of Gbps. From latency perspective, 5G supports service which are not sensitive to packet delay and services which require very low end-to-end latency. From the perspective of mobility, high Quality of Service (QoS) services are to be supported in the situations of ultra high-speed. The challenge is to support wide range of services, scenarios and use cases in a single standardized system.

- **Radio Access Solutions**

We see the following benefits of Radio Access Solutions:

- **Networked Society**

5G will enable the long-term Networked Society and realize the vision of unlimited access to information for anyone and anything. This vision will be achieved by combining evolved versions of today's radio-access technologies (RATs), including LTE and HSPA, with complementary RATs for specific use cases and not by replacing existing technologies [18]. 5G radio access will take user experience and overall system performance a step beyond what 4G can currently provide.

- **High Mobile-Broadband Service Level**

The present mobile technologies such as 3G, LTE, and HSPA etc. will continuously improve and provide the foundation to the overall radio access solution in future. Their capabilities will keep on growing and expanding. The mobile broadband technologies will also expand into new development scenarios, such as dense small-cell deployments, and new use cases, such as different kinds of machine-type communication.

- **Ultra-High Traffic Capacity and Data Rates**

In order to efficiently tackle the challenge of facilitating extremely high traffic capacity and ultra-high data rates, we foresee the introduction of ultra-dense network deployments which incorporates operating nodes with wide transmission bandwidth in higher frequency bands that depend upon the new radio access technologies [19]. To reliably support ultra-high data rates, ultra-dense networks should facilitate minimum transmission bandwidths of minimum 100MHz or more. Ultra-dense networks will primarily operate in the 10-100GHz range.

- **Low-Power Machine-Type Communication Devices**

Currently 3GPP is working on projects focusing on mobile broadband technologies that support a large number of low-power machine-type communication devices [18]. However, LTE technology cannot be evolved to an extent up to which it can meet certain extreme requirements. This will give rise alternative technologies. These technologies will then be integrated in mobile technologies in order to provide proper connectivity.

- **Ultra-Reliable Communication**

The reliability of communication depends on the deployment of networks and the provision of affluent resources to handle peak level traffic [18]. A significant challenge lies in the combination of ultra-low latency and reliability. This will require different tradeoffs than the ones currently being used in the mobile systems [18]. Control-channel design, coding, link adaptation and Radio Resource Management are areas in which tradeoffs will need to be made differently to optimize networks and ensure low latency.

- **Energy Efficiency and Sustainability**

Taking into account its importance, energy efficiency must be the main target of 5G radio access solutions [18]. Reduced link distances in a densified network as well as smart functionalities for node sleep and minimization of signaling for network detection and synchronization will significantly bring down the energy consumption of future networks.

- **LTE with HSPA**

In the years to come, several telecom operators will have a joint LTE and UMTS network deployment, which requires LTE/HSPA resource management in order to accommodate seamless multi-RAT operation to fit in both voice

calls and SMS services, as well as high bit rate packet switched data services [3]. More exchange of information will provide mobility and service continuity for user experience and performance consistency across different RAT [15].

LTE with HSPA interworking results in an efficient information co-ordination. There are two modes of connectivity idle mode and connected mode. In the idle mode, the UE's select the RAT autonomously, based on broadcast information. The UE's perform cell reselection based on measurements of the quality of serving and target RAT's. An RAT is selected based on its quality, if the quality is good and higher than the priority of the serving RAT [22]. Due to this, idle UE's in HSPA can select and reselect LTE in areas of LTE coverage.

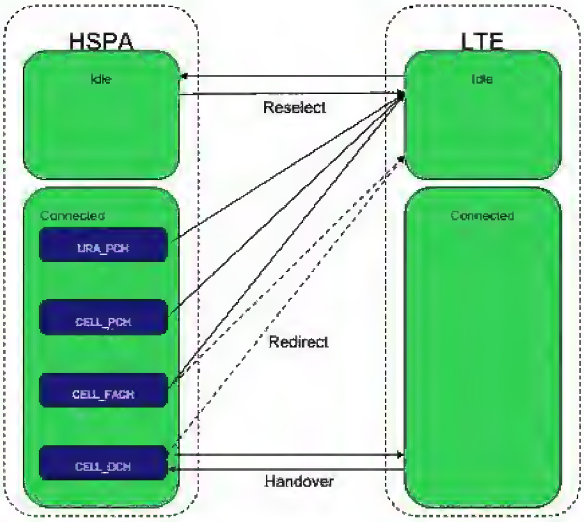

Figure 5

In the connected mode, it can be transferred to HSPA with the help of inter-RAT handover or inter-RAT redirection procedure. The handover generates an interrupt in communication that lasts for few milliseconds. This is achieved through the reservation of resources in target cell before the serving cell is released and the data is forwarded from the serving RAT to the target RAT. After the RAT handover [22], the UE ends up in the RRC state CELL_DCH in WCDMA and ends up the routing area so that it can reached in a new RAT. This procedure can also be used to direct UE from the CELL_DCH in WCDMA to LTE. After the inter-RAT redirection procedure [22], an outage is performed before the inter-RAT HO procedure. This outage is a routing area update and no data transmission takes place in this time period. When a UE is in any one of the RRC states CELL_PCH, CELL_FACH or URA_PCH, it performs cell reselection [22]. Thus, whenever the UE reselects an LTE cell, it enters the idle mode and gets an access to the LTE cell.

An efficient information coordination would lead to reliable mobility, transparent user experience service continuity and performance consistency across a seamless LTE/HSPA single network. Thus, it is possible to provide up to 5 GB of data per month for every existing voice subscriber by using HSPA and LTE radios in existing sites.

CONCLUSIONS

5G is on its way and rather than being another 'next generation' it will be a better integration of old and new technologies. The 5G system for 2020 and beyond will meet the long-term vision of unlimited access to information and sharing of data available anywhere and anytime to anyone and anything. To do this, it is clear that a much wider variety of devices, services and challenges than those accommodated by today's mobile-broadband systems will have to be addressed. Due to this diversity, the 5G system will not be a single technology but rather a combination of integrated

RATs, including evolved versions of LTE and HSPA, as well as specialized RATs for specific use cases [17], which will jointly fulfill the requirements of the future. This integration of different systems will enable more stringent requirements in some areas to be met, relaxed needs in others, with a focus on keeping overall costs and energy dissipation low.

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